



Iron Silicate

Circular mineral for climate-friendly construction



Iron Silicate

Introduction

Did you know that iron silicate is a prime example of tomorrow's circular and climate-friendly construction industry?

The European construction industry urgently needs local, low-carbon raw materials to meet decarbonization targets and reduce dependence on imported and/or natural materials. Iron silicates offer a safe, reliable, circular, sustainable and technically sound alternative that fits seamlessly into existing cement and concrete systems. With regulatory support and standardization alignment, these engineered minerals can help Europe accelerate its path to climate neutrality.

What is iron silicate?

- » Industrially manufactured mineral, a by-product of refining and recycling during our copper production processes
- » Similar properties to natural aggregates
- » Already widely used in numerous applications such as civil engineering and road construction, hydraulic engineering, and sand blasting
- » Use in the construction industry is still limited and country specific due to non-harmonized and partially outdated regulations

What iron silicate products are produced?

More than 1 million t of iron silicate products are fabricated at the German and Belgian Aurubis sites.



Stones & minerals with edges up to 0.5 m in length or as crushed minerals, comparable to igneous rock



Granules similar to natural volcanic glass, e.g., obsidian



Fines similar to mineral flour

Aurubis is ready to further develop iron silicate as an alternative to natural materials for the construction industry.



Hydraulic engineering

Road construction

Cement production

Concrete production

Advantages

for the construction industry

Impact on climate protection and decarbonization

- » Lower carbon footprint compared to natural materials
- » Local use as aggregate significantly reduces CO₂ by minimizing transport of natural materials from quarries, e.g., from Scandinavia
- » Life cycle assessment shows that replacing natural materials with iron silicate in concrete can reduce its CO₂ footprint by up to ~10 %
- » Contribute to EU Green Deal: When used as SCM (supplementary cementitious material), iron silicate can significantly reduce clinker content, lowering the cement's CO₂ footprint — e.g., it can replace ~35 % of CEM I (cement production is responsible for approximately 8 % of global CO₂ emissions today, significantly impacting climate change). This makes it a viable alternative to other reduction options, like GGBFS or fly ash, which are also often imported to Europe.

Economic and strategic benefits for Europe

- » Iron silicates are locally produced in Europe, generated continuously, and available in stable volumes, so they can reduce dependence on imports
- » Local iron silicate production strengthens Europe's industrial resilience and strategic autonomy

Impact on resource conservation & circularity

- » Full use of material from copper production = true circular economy. Repurposing iron silicates supports circular economy targets and offers ecological and economic advantages.
- » Reduces extraction of scarce natural materials, land use, and impact on ecosystems
- » Verifiably better life cycle assessment than natural rock

Safe, proven and technically sound

- » Iron silicate is registered under the EU REACH chemicals regulation and classified as non-hazardous
- » Demolition allows for single-type reuse as recycled concrete or building material in road construction
- » Extensive technical testing shows good performance in concrete and cement applications
- » Certified environmental leaching (elution) tests confirm that its use is safe and compliant: negligible substance release, no environmental hazards
- » Preliminary Environmental Product Declarations are available from IBU; verification ongoing
- » Recycling can promote closed material cycles in the construction industry in the long term, fostering industrial symbiosis



Use Case 1

Demo walls with iron silicate as concrete aggregate



Project:

- » Industrial-sized, steel-reinforced concrete walls (0.3 m thick) showcase the suitability of concrete made with iron silicate
- » 2 walls with iron silicate minerals 4/8 (28 weight %) and 2 walls with iron silicate granules 0/4 (20 weight %)
- » Partners: Alster Beton GmbH (concrete recipe, civil works, concrete production, transportation and casting); Engineering Consultancy Schiessl · Gehlen · Sodeikat GmbH; Peute Baustoff GmbH; Aurubis AG

Manufacturing process assessment

Evaluation from a concrete technology perspective — expert opinion from Engineering Consultancy Schiessl · Gehlen · Sodeikat GmbH, Munich, Feb. 4, 2025

- » Both types of concrete exhibited good fresh and hardened concrete properties for practical construction applications
- » Transport and pumpability were fully satisfactory
- » Good sedimentation and compaction behavior
- » Good performance with regard to placement under the prevailing winter temperatures

Environmental studies

For pure aggregate, concrete produced from it, and recovered recycled aggregate — FEhS, Institut für Baustoff-Forschung e.V. (ongoing)

- » Elution tests of concrete samples and of recycled fractions confirm adherence to ABuG limits

Service life assessment

Concrete containing iron silicate — ARCHE Consulting, May 2025

- » The use of iron silicate (comment: e.g., drilling or cutting) in concrete up to 30 % does not lead to risk characterization ratios above 1 (comment: no risk for ratios below 1) for the occupational exposure assessment.
- » Risks for the environment are considered negligible

Recycling

- » Investigations on end-of-life concrete — Institute of Advanced Minerals Processing at RWTH Aachen (ongoing)

Durability of concrete

Expert opinion of Engineering Consultancy Schiessl · Gehlen · Sodeikat GmbH, Munich, Dec. 9, 2025

- » “The normative requirements for the properties of the aggregate are demonstrated for the use of the iron silicate aggregates evaluated here (grade numbers 201, 204, and 205) in all exposure classes according to DIN 1045-2:2023”
- » Beyond the normative requirements, iron silicate aggregate offers durability-related advantages with regard to:
 - › Chemical attack — Thaumassite formation: Very low carbonate content (traces)
 - › Frost and de-icing salt resistance: Very low weathering in material testing, low water absorption, low friable fraction of crushed particles due to production
 - › High Mohs hardness of the granules — beneficial for mechanical stress on concrete surfaces

Next step:

Construction of a locker room (Waschkaue) as the first flagship building using iron silicate aggregates in concrete at Aurubis Hamburg; already granted single-case approval by the Hamburg authorities.

Use Case 2

Floor of an industrial building at Aurubis Beerse with iron silicate as SCM (supplementary cementitious material)



Project:

- » Casting of two concrete surfaces using iron silicate as SCM in concrete
- » Water-tank slab (~30 m³) and storage-building floor and plinths (~75 m³): cast in two phases (plinths followed by floor) with a 2–3 week interval; the final floor was polished
- » Close collaboration between Fluor Engineering engineering office, ResourceFull technology company, Janssens Beton concrete plant, VanHout. pro civil contractor, 3D Architecten architects, and Aurubis Beerse throughout large-scale production

Evaluation of the manufacturing process

Concrete-technology evaluation — ResourceFull led the technical developments and helped coordinate the practical implementation

- » Mix design: 105 m³ of concrete produced using 50 tons of preblend containing iron silicate in addition to CEM I, GGBFS and activator. The optimal mix was defined after extensive laboratory development and trial batches at the concrete plant, allowing fine-tuning based on execution requirements
- » Mix development: two mixes were refined:
 - » A wall mix for the pit walls with a slow hardening profile and 50 % iron silicates as binder
 - » A floor mix suitable for polishing with 30 % iron silicates as binder
- » Durability: tested in accordance with NBN 15-100 and for C35/45 EE2 S4 performance requirements; all parameters complied with the equal concrete performance concept
- » ResourceFull provided on-site support during execution to guide the process and ensure correct implementation
- » The mix demonstrated excellent fresh-property performance, including stable workability with a slump retention of 120 minutes at S4 consistency in accordance with NBN EN 12350-2

Long-term studies

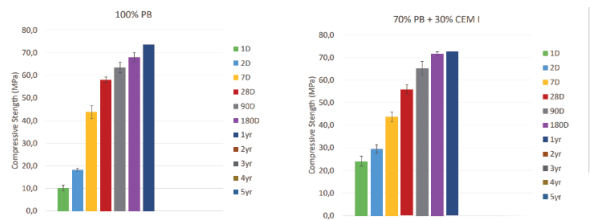
Samples were taken and all relevant tests performed in consultation with stakeholders to ensure continuous quality monitoring (ongoing up to 5 years after implementation)

Mechanical properties: samples are tested for strength development in accordance with EN196-1 and EN197-1

- » Compressive strength in accordance with EN196-1 (1, 2, 7, 28, 90, 180 days and 1, 2, 3, 4, 5 years after production) (ongoing) → all concrete batches showed constant quality, far exceed the standard requirements for C35/45 at all ages, and demonstrated excellent long-term strength gain

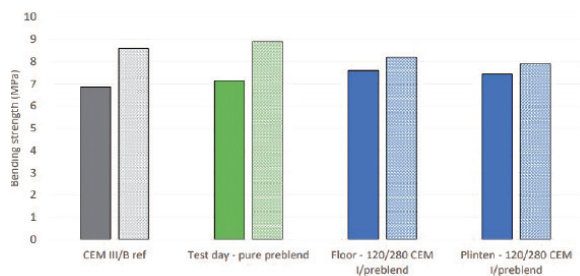
Compressive strength follow-up: average until 1 year*

To be continued...



- » Bending strength in accordance with EN 12390 (28 days, 1 year) → bending strength results were excellent and continued to increase after 1 year

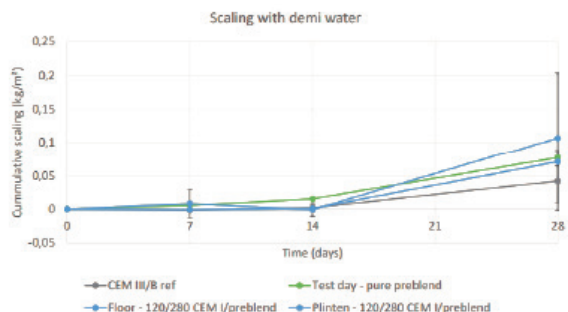
Bending strength continued to increase after 1 year*



The following additional durability tests were conducted:

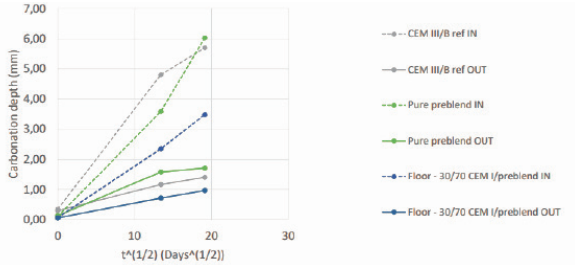
- » Freeze-thaw behavior without de-icing salt (EE3) in accordance with CEN/TR 15177:2006 (ongoing) → low cumulative scaling after 28 days showed good freeze-thaw resistance. Tests with de-icing salt (EE4) indicated that mix is not recommended for chloride-exposed surfaces

F/T behavior without de-icing salt (EE3)*



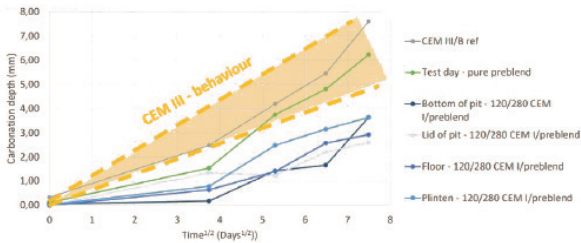
- » Natural carbonation resistance for inside storage and outside natural weathering in accordance with NBN EN 13295 up to 5 years after production (ongoing) → good performance

Natural carbonation*



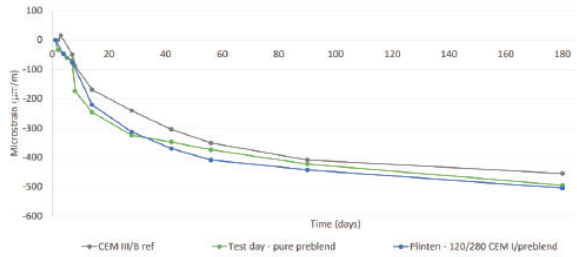
- » Accelerated carbonation in accordance with NBN EN 13295 → outstanding carbonation resistance (low carbonation depth)

Accelerated carbonation*



- » Shrinkage testing in accordance with NBN B 15-216 → lower shrinkage than reference

Shrinkage behavior*



Environmental studies

Leaching tests for first and second life applications were conducted to meet OVAM requirements for obtaining a raw materials declaration → all values were well below the limits.

Next step (already in progress):

Attaining an ATG (independent technical approval that assures the product quality and performance meet recognized, certified standards in construction) from Procertus is the next milestone. This will confirm for market actors that using Aurubis iron silicate as SCM is a proven, safe, high-quality, and low-carbon option for concrete and cement.



What sets Aurubis apart:

- » Security of supply — Reliable, resilient and global delivery, even in volatile markets.
- » Quality leadership — Ensuring high standards through operational excellence and continuous improvement.
- » Sustainability leadership — Driving responsible growth with measurable ESG impact across the value chain.
- » Digital solutions — Driving the adoption of digital tools that simplify collaboration and transactions.
- » Financial robustness — A strong balance sheet enabling long-term partnerships and investment stability.
- » Service excellence — Fast, proactive and solution-oriented support across every customer touchpoint.
- » Price risk management — Flexible copper price fixation models, including Copper on Account, ensuring transparency, hedging security, and supply chain flexibility.
- » Flexible logistics solutions — Tailored, efficient and resilient delivery concepts aligned with your production and planning needs.

For our vision of a future-proof, sustainable metals Industry – Tomorrow Metals.

- » Tomorrow Metals is our Aurubis sustainability promise. It is a symbol of our commitment to transform the metals industry — by sourcing and producing materials responsibly, with a deep sense of purpose.
- » Our **Aurubis sustainability promise** is based on four pillars:
 - » **Responsibility** — Everything we do focuses on a balance of economy, environment and people.
 - » **Environmental Impact** — We are committed to delivering more value with less environmental footprint.
 - » **Decarbonization** — We ensure transparent and measurable progress in our emission reductions towards net zero.
 - » **Circularity** — We expand multimetal recycling to conserve natural resources and strengthen the circular economy.



Shaping Tomorrow.
Together. Today.

aurubis.com/tomorrowmetals



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